ORIGINAL

ORIGINAL

LAW OFFICES

LEVENTHAL, SENTER & LERMAN P.L.L.C.

EX PARTE OR LATE FILED

SUITE 600

2000 K STREET, N.W.

WASHINGTON, D.C. 20006-1809

NORMAN P. LEVENTHAL
MEREDITH S. SENTER, JR.
STEVEN ALMAN LERMAN
RAUL R. RODRIGUEZ
DENNIS P. CORBETT
BRIAN M. MADDEN
BARBARA K. GARDNER
STEPHEN D. BARUCH
SALLY A. BUCKMAN
NANCY L. WOLF
DAVID S. KEIR
DEBORAH R. COLEMAN
NANCY A. ORY
ROSS G. GREENBERG
H. ANTHONY LEHV
JOHN D. POUTASSE
CHRISTOPHER J. SOVA
PHILIP A. BONOMO
JUAN F. MADRID
JANET Y. SHIH
JENNIFER A. MERRILL

TELEPHONE
(202) 429-8970

TELECOPIER
(202) 293-7783

WWW.LSL-LAW.COM

March 22, 2001

RECEIVED

MAR 22 2001

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Ms. Magalie R. Salas, Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: <u>Oral *Ex Parte* Presentation in ET Docket No. 98-206</u>

Dear Ms. Salas:

Pursuant to Section 1.1206 of the Commission's Rules, 47 C.F.R. Sec. 1.1206, Virtual Geosatellite LLC, through counsel, provides notice that on March 20, 2001, Mr. Gerald Helman, Mr. Jay Brosius and the undersigned, met with members of the International Bureau copied below to discuss proposed virtual geosatellite orbital tolerances per the attachments to this letter.

The original and one copy of this letter with attachments are submitted for inclusion in the record of the referenced proceeding.

Please contact the undersigned with any questions.

Respectfully submitted,

~~Raul~~ R. Rodriguez
Counsel to Virtual Geosatellite, LLC

RRR/rjc
Attachments (2)

cc (by e-mail w/ attach.): Thomas S. Tycz
Cecily Holiday
Jennifer Gilsenan
John Martin
Alex Roytbalt
Mark Young

No. of Copies rec'd 0+1
List A B C D E

Orbital Definition and Tolerances

This paper summarizes a suggested approach to defining VGSO allocations and their tolerances.

Discussion:

Earlier papers have suggested an approach to defining VGSO assignments (see "Response to Questions regarding VGSO," 23 February 2001). This discussion attempts to apply meaningful tolerances to a VGSO assignment.

Simulation studies have shown that variations in orbital elements interact (as would be expected) to produce a net effect in satellite movement, as seen from Earth Stations. As expected, small perturbations in right ascension, argument of perigee, or mean motion alone, for example, can produce significant movement out of track and out of timing for a VGSO satellite. However, further analysis demonstrates that certain combinations of orbital perturbations can substantially counteract each other and result in relatively small net movements over much (but usually not all) of the active arcs. An example is certain combinations of perturbations to mean anomaly and argument of perigee. Therefore it does not appear feasible to specify easily measurable, two-dimensional parameters as seen from the ground at specific times (such as azimuth and elevation parameters at a specified active arc entry and/or exit time) and guarantee acceptable performance over the entire active arc in the face of perturbations to the satellite's orbit.

It might of course suffice to specify a full set of orbital parameters and place tolerances on each of them, but that approach then does not lead to easily observable, measurable, or verifiable characteristics without doing a full orbital mechanics analysis. Therefore, to avoid overly esoteric tolerance specifications while protecting against poorly performing but in-spec possibilities, the most workable approach to specifying tolerances involves placing limits on in-track and cross-track offsets applicable at all times within the active arcs. This has the desirable effect of ensuring accurate satellite placement while ignoring any perturbations that are not relevant to that objective.

Note that any tolerance specification should only concern measurement within the active arcs. At other times the satellites are quiescent, hence interference and orbital accuracy are not issues. Moreover, when quiescent, satellites may not be able to participate in ranging, telemetry or other activities designed to aid in position determination, unless that function critical to the satellite attitude is not quiescent in the inactive portion of the orbit, or at least not in the entire inactive portion of the orbit.

The following are suggested parameters for defining and assigning allocations within the VGSO operating environment. The tolerances below yield generous station-keeping boxes while ensuring tight-enough tolerances on satellite movement so as not to contribute significantly to adjacent satellite interference levels over nominal values.

Specification:

1. All assigned orbits shall conform to the following characteristics:

Mean Motion	3.000
Inclination:	63.435°, specifically that required to ensure a fixed argument of perigee in a posigrade orbit
Eccentricity:	0.630
Argument of perigee:	270° for Northern arcs (ground tracks 1a and 2a) 90° for Southern arcs (ground tracks 1b and 2b) (see 2 below)
Longitude of Apogee over Americas:	65°West (ground tracks 1a or 1b, occurring at 180° Mean Anomaly), or 125°West (ground tracks 2a or 2b, occurring at 180° Mean Anomaly), as assigned

2. Allocations may occur in any of four ground tracks:

Ground Track	Argument of Perigee	Longitude of Apogee over Americas
1a	270°	65°W
1b	90°	65°W
2a	270°	125°W
2b	90°	125°W

3. Each satellite may operate over an active arc spanning 72° to 288° of Mean Anomaly within its orbit, plus the three minutes of time preceding 72° Mean Anomaly and 3 minutes of time following 288° of Mean Anomaly. At all other times each satellite must suppress all radiation by at least 60 decibels below that authorized during operation in the active arc.

4. Each authorized satellite shall be allocated a time on the first of January 2005 at which it shall arrive at 72° Mean Anomaly in its orbit within the Americas Active Arc for its assigned Ground Track. The time of arrival at 72° Mean Anomaly on other days may be calculated by adding or subtracting an appropriate integer number of sidereal day intervals (i.e., that time necessary for the earth to rotate precisely once with respect to the stars, being approximately 23 hours and 56 minutes) to result in a time within the desired day.

5. Allowable orbital tolerances

In-Track Tolerance	No satellite shall arrive at any point within any active arc at a time more than 45 seconds removed from that predicted by the satellite's assignment, over the lifetime of the satellite.
Cross-Track Tolerance	No satellite shall move out of track by any more than 0.1 degrees as seen from any point on the earth, from that track predicted by the satellite's assignment, over the lifetime of the satellite.

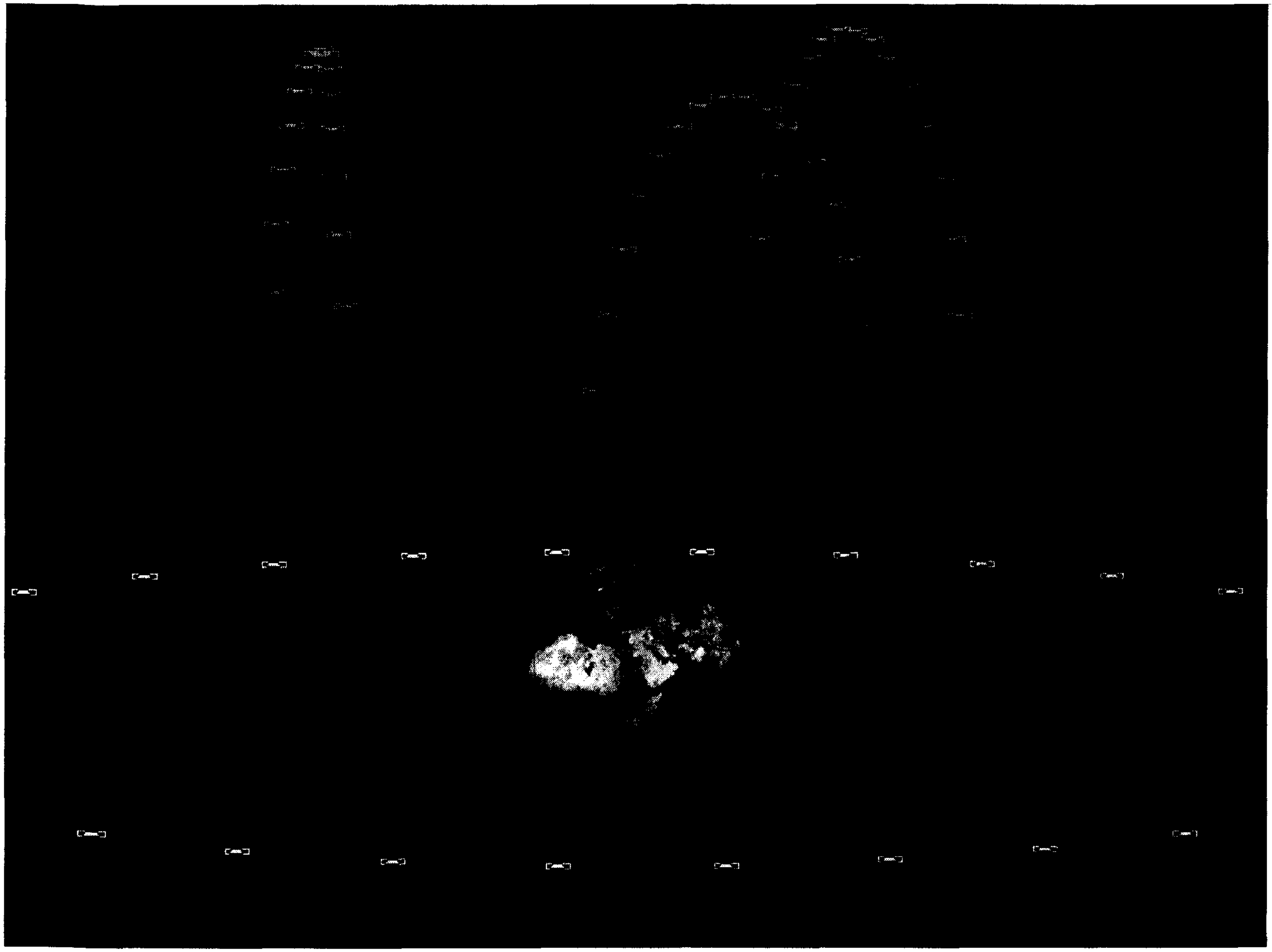
VGSO Orbital Specification and Allocation

March 20, 2001

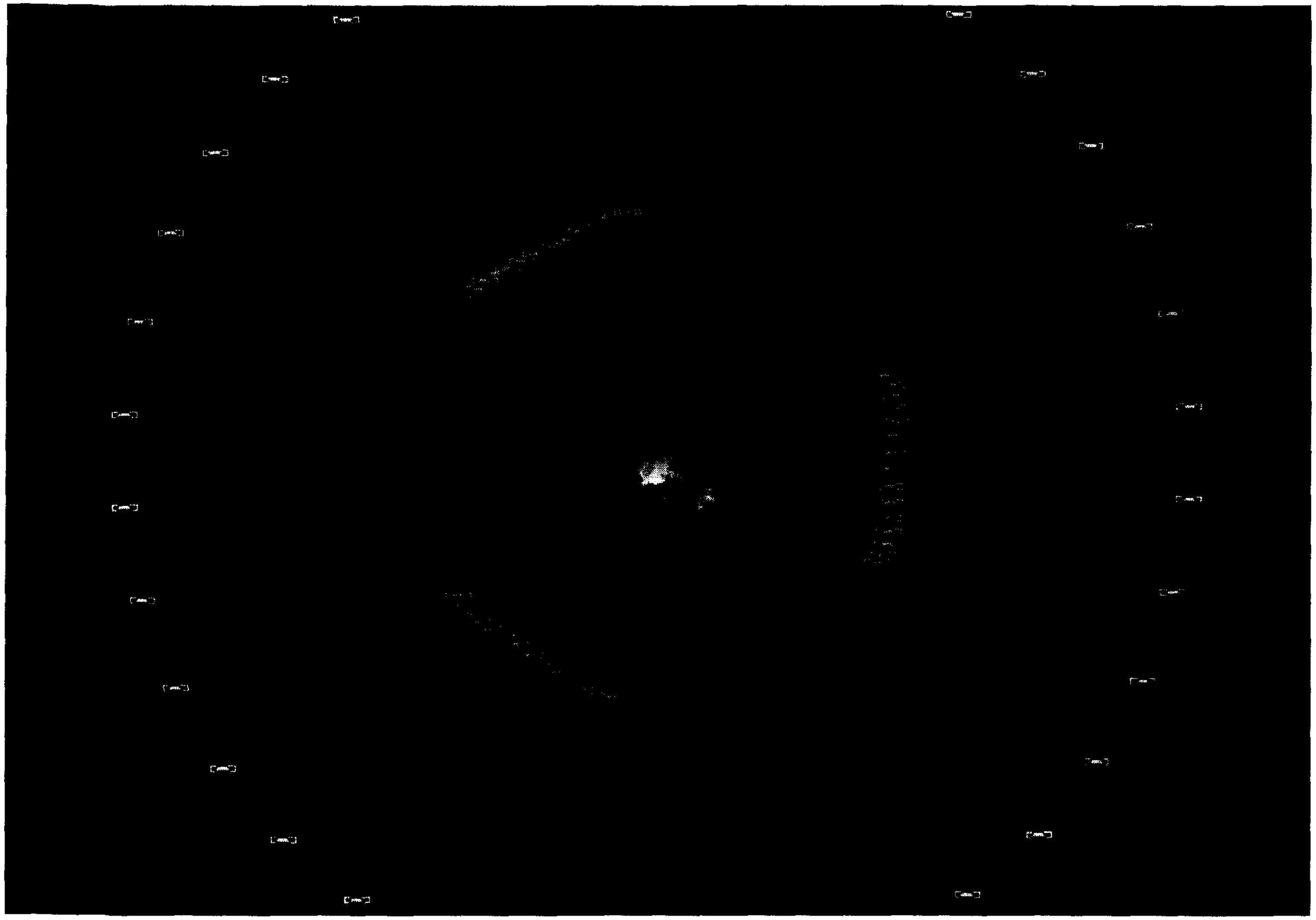
The VGSO Regime

- Non-geostationary allocations that
  - Reuse geostationary FSS allocations
  - Avoid any crossing interfererence
    - VGSO to GSO
    - VGSO to VGSO
  - Permit up to 50+ hemispheric allocations
    - 150+ regional allocations
    - 25+ global, bi-hemispheric allocations
  - Using GSO-analogous sharing criteria
    - Minimum angular separations
    - Earth station antenna pattern masks
    - Along-track and cross-track tolerances
  - Using time-of-entry into specified arc on date rather than longitude

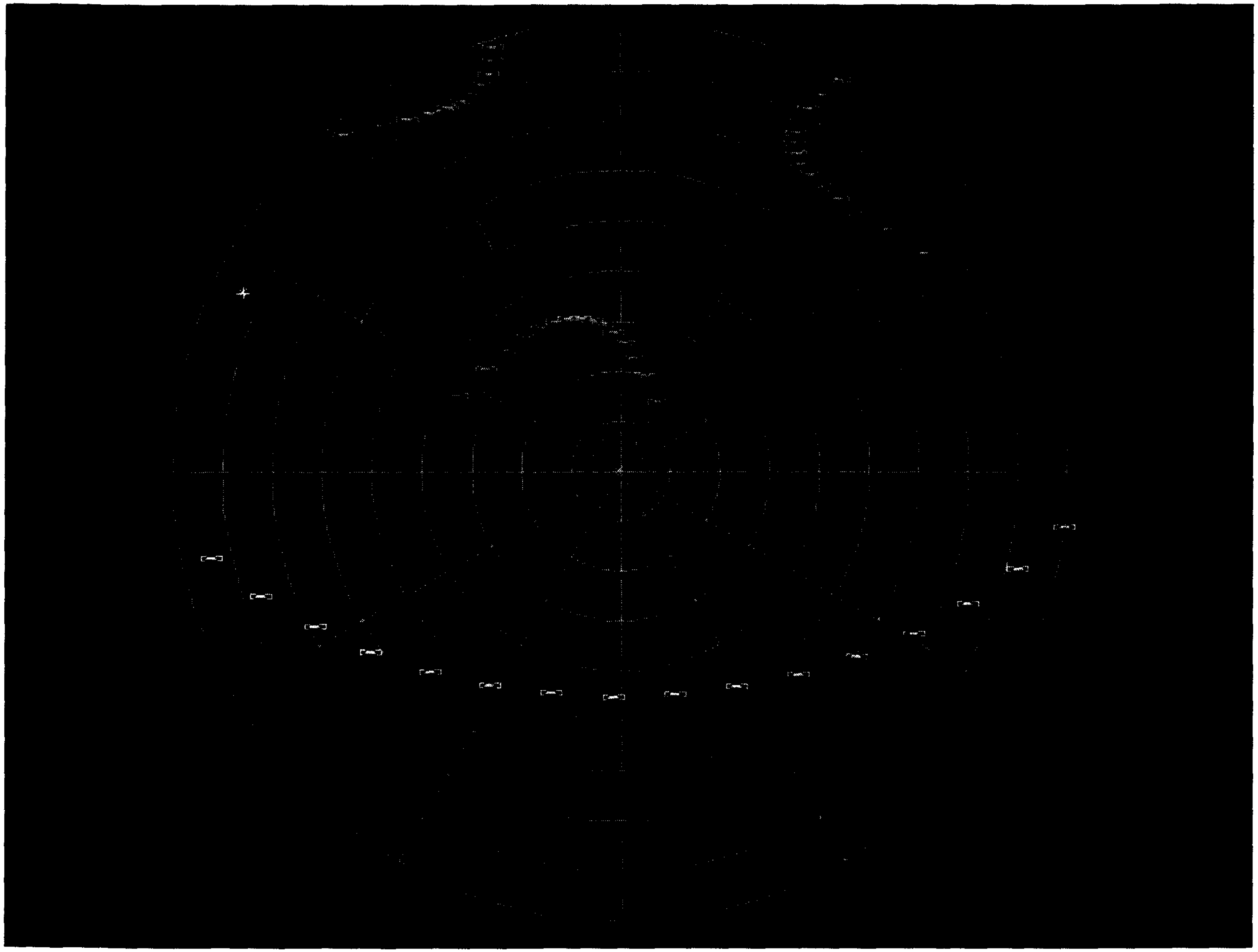
Virtual GEO Satellites in Perspective



Virtual GEO Slots from the North



Virtual GEO Satellites from Washington

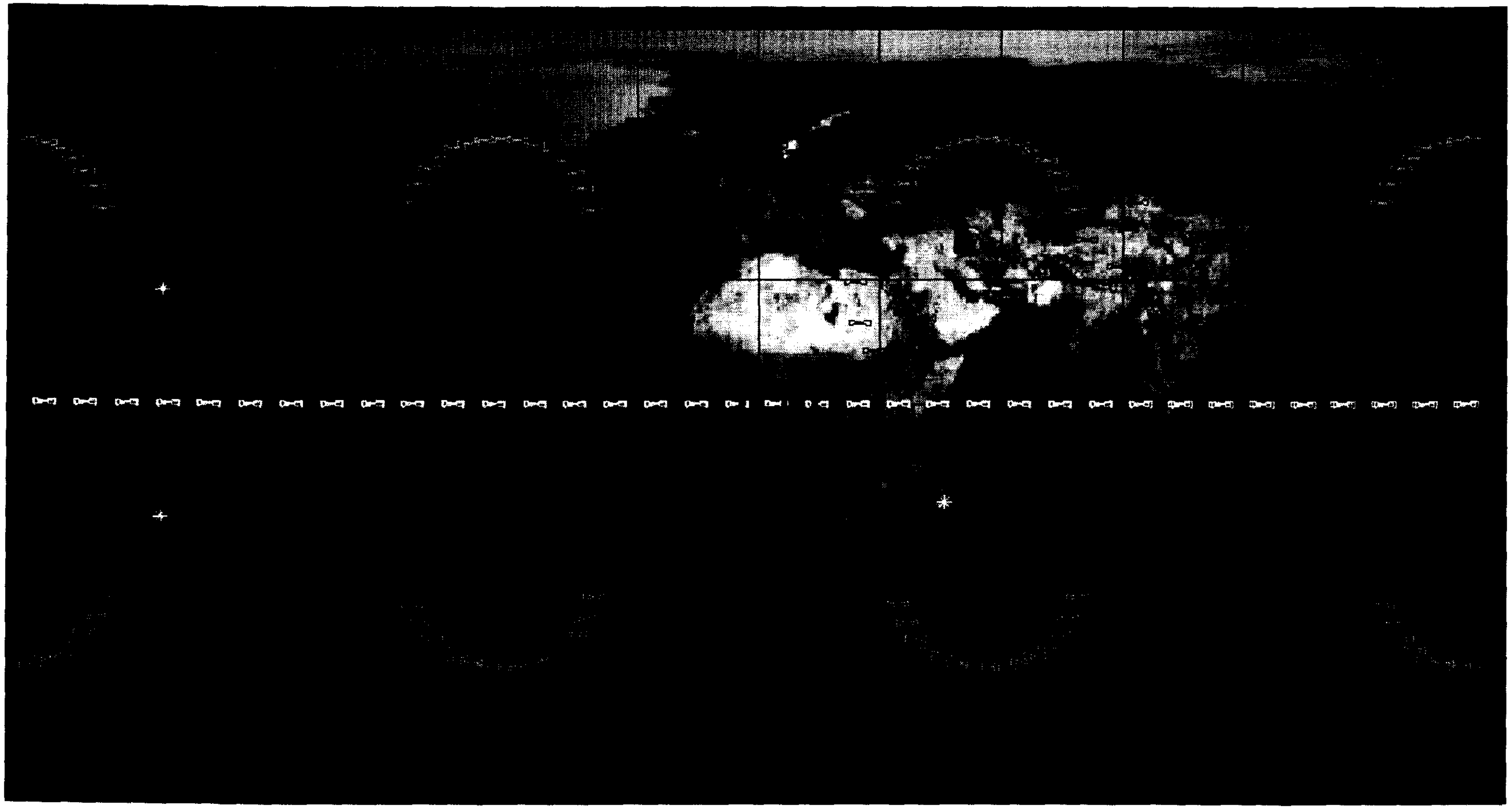


Standard Orbital Parameters

Mean Motion	3.004: freeze ground track (including correction for regression of nodes to freeze ground track)
Inclination	63.435°: freeze apogee (to freeze rotation of line of apsides)
Eccentricity	0.63: perigee > 1000 km
Argument of Perigee	270 degrees – Northern arcs 90 degrees – Southern arcs
Longitude of Apogee over Americas	65 or 125° West Longitude defines coverage areas

Note: slight adjustments may be needed persuant to further high precision perturbation analysis

Active Arcs



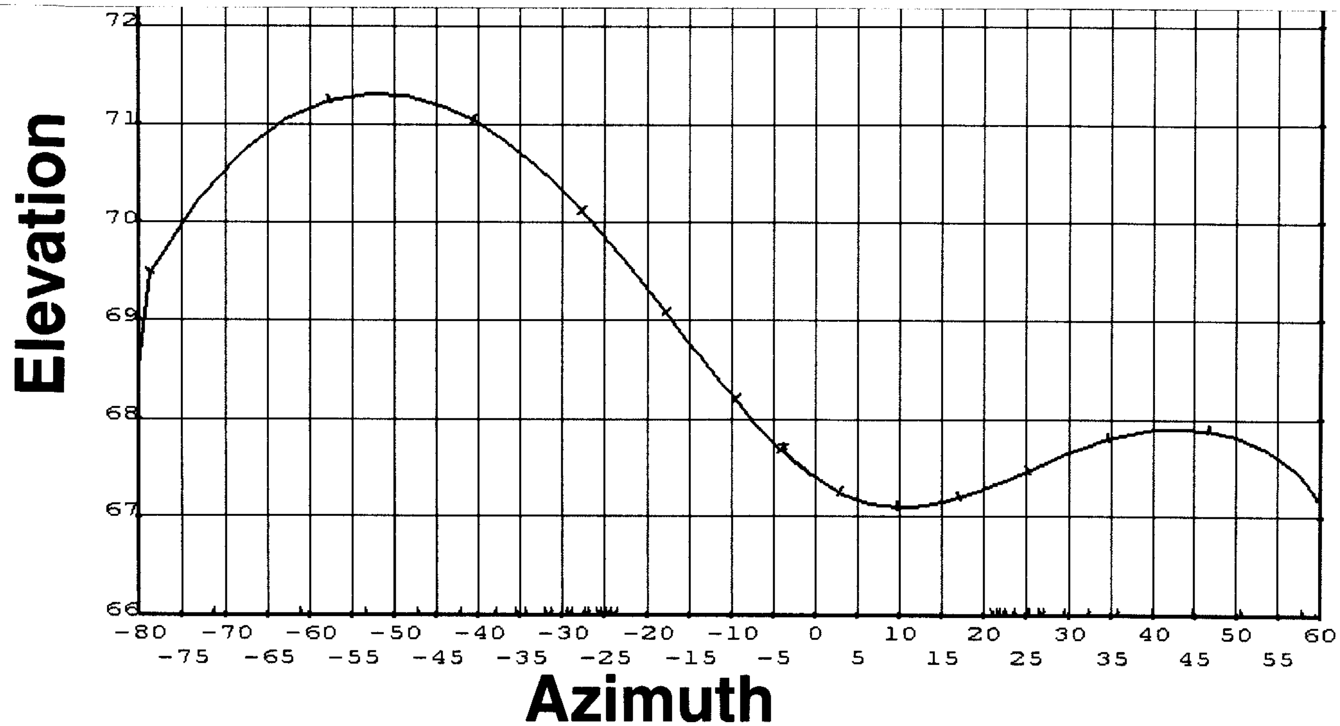
Active Arcs

- Longitude of Apogee specified for Americas Active Arcs
  - 65° West for Ground Tracks 1a and 1b
  - 125° West for Ground Tracks 2a and 2b
- Other two Active Arcs in ground track offset by ±120 degs
- Active Arcs span 72 to 288 degrees Mean Anomaly for each assigned orbit
  - Plus 3 minutes at each end of Active Arc for switchover, housekeeping
  - Satellite RF Radiation suppressed by at least 60 decibels relative to authorized power when out of Active Arc
- Each Assignment granted an Americas Active Arc time of entry for January 1, 2005
  - Time separation provides angular separation
  - Entry time can be calculated for other days as needed

Create Standard Active Arc Tracks
as Basis for Allocation

- Track in space based on earlier orbit parameters
- Defined entry and exit points
- Defined allocation spacing (time intervals)

Standard Active Arc example (seen from earth):



Defining Tolerances
The Effects of Orbital Inaccuracies

Red is Standard Orbit

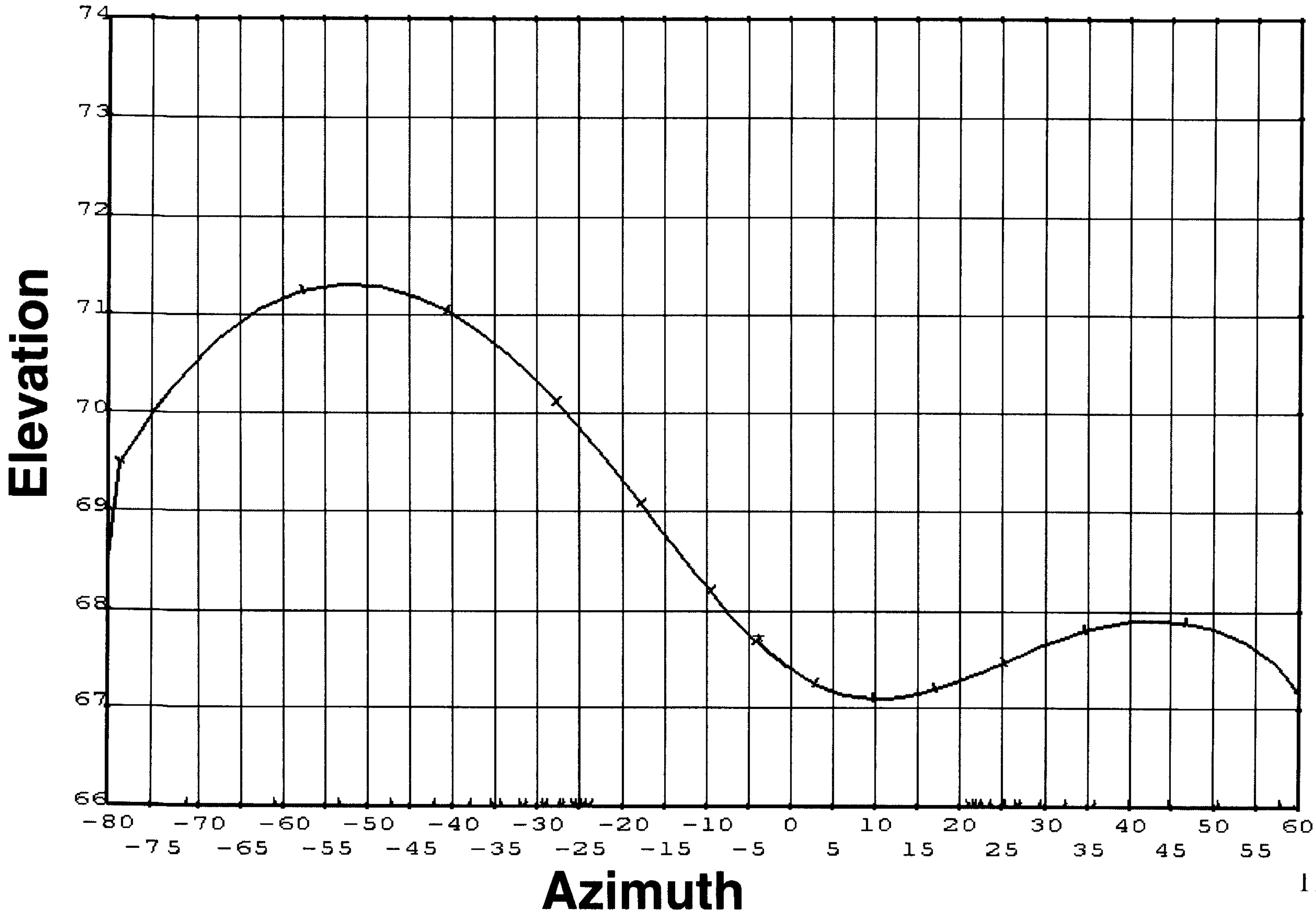
Green is inaccurate variation

Ticks are example satellite positions

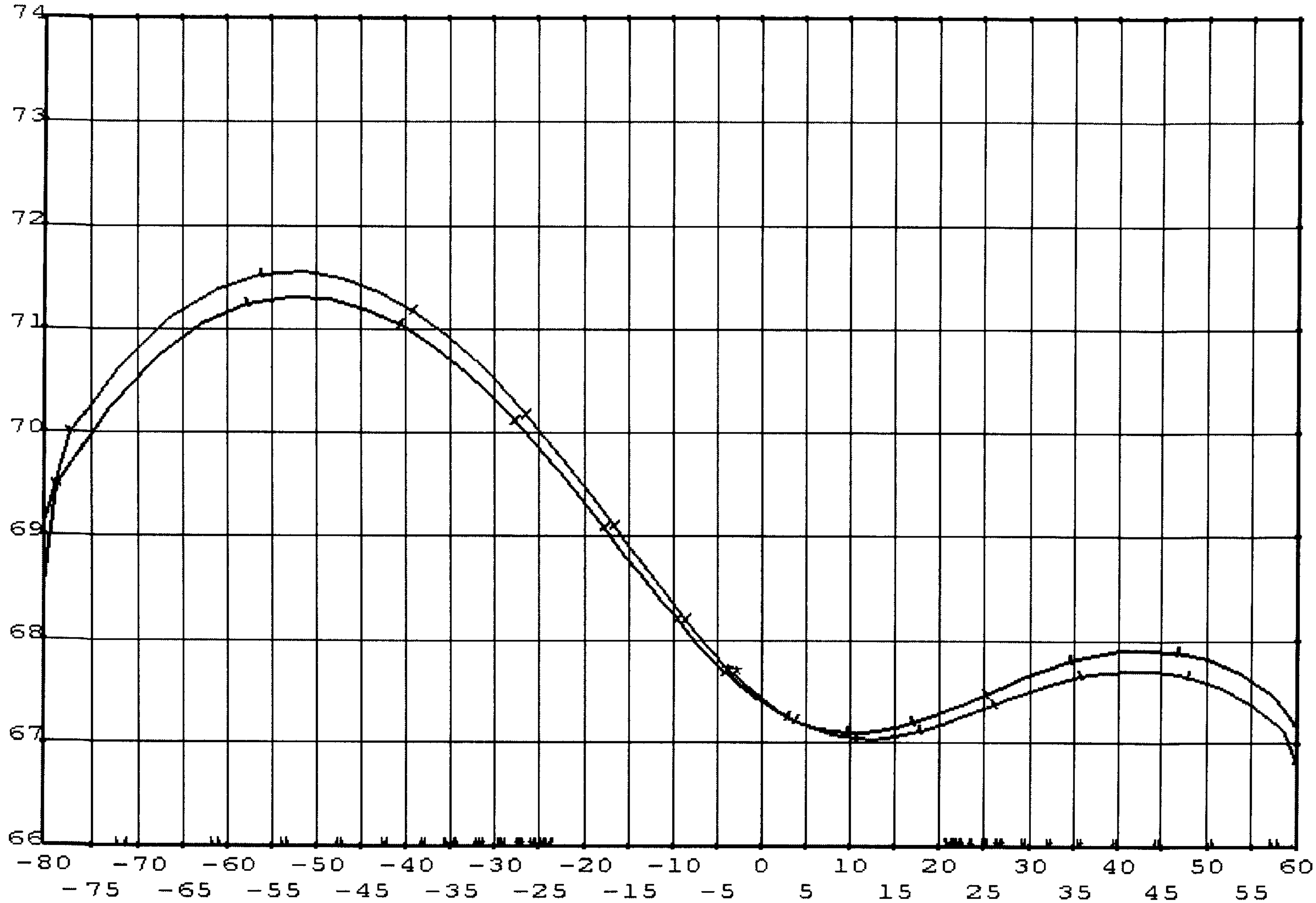
Northern Active Arc seen from arbitrary location at 45^{o} N

An Active Arc Standard Pass

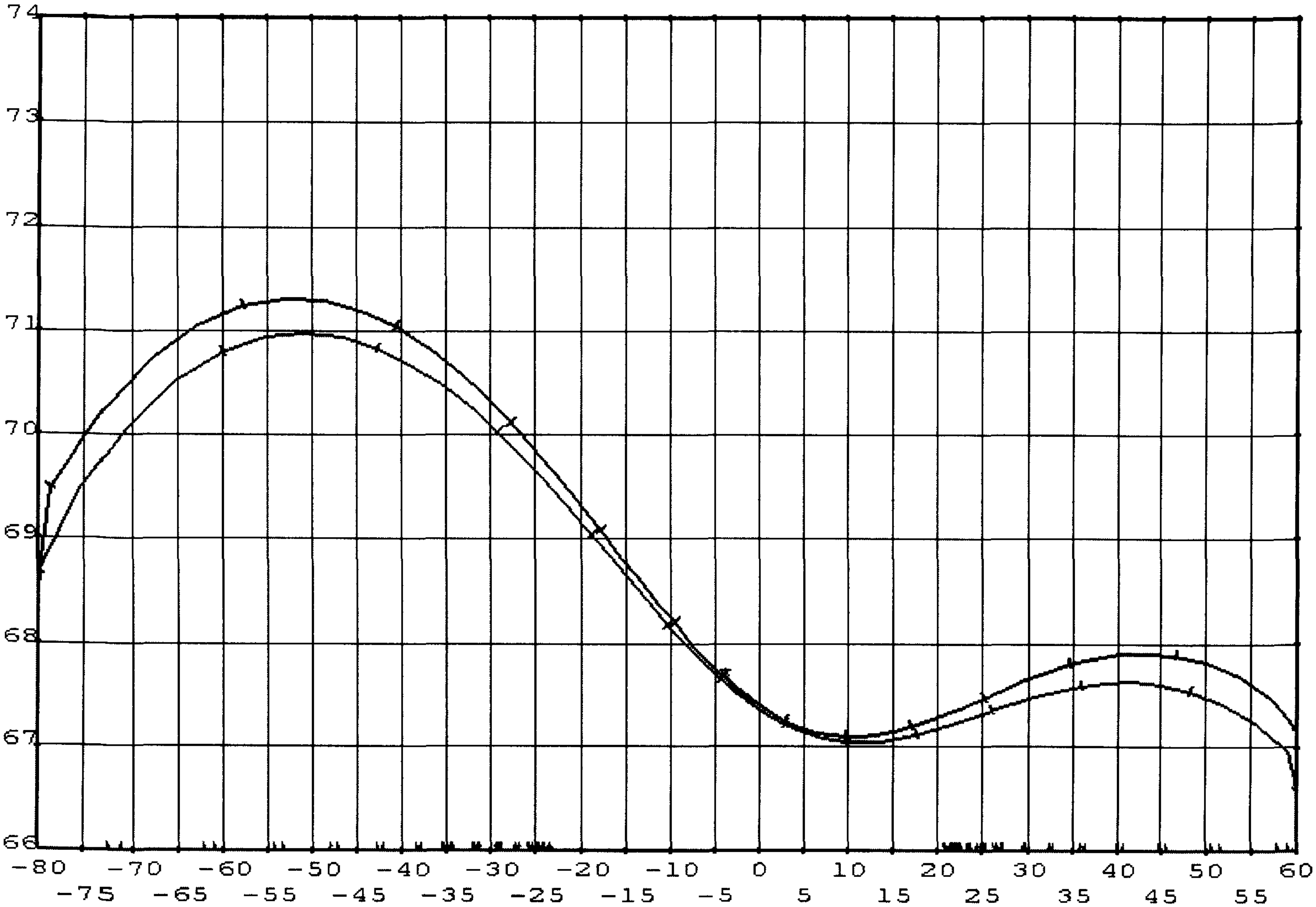
(Rectangular Plot)



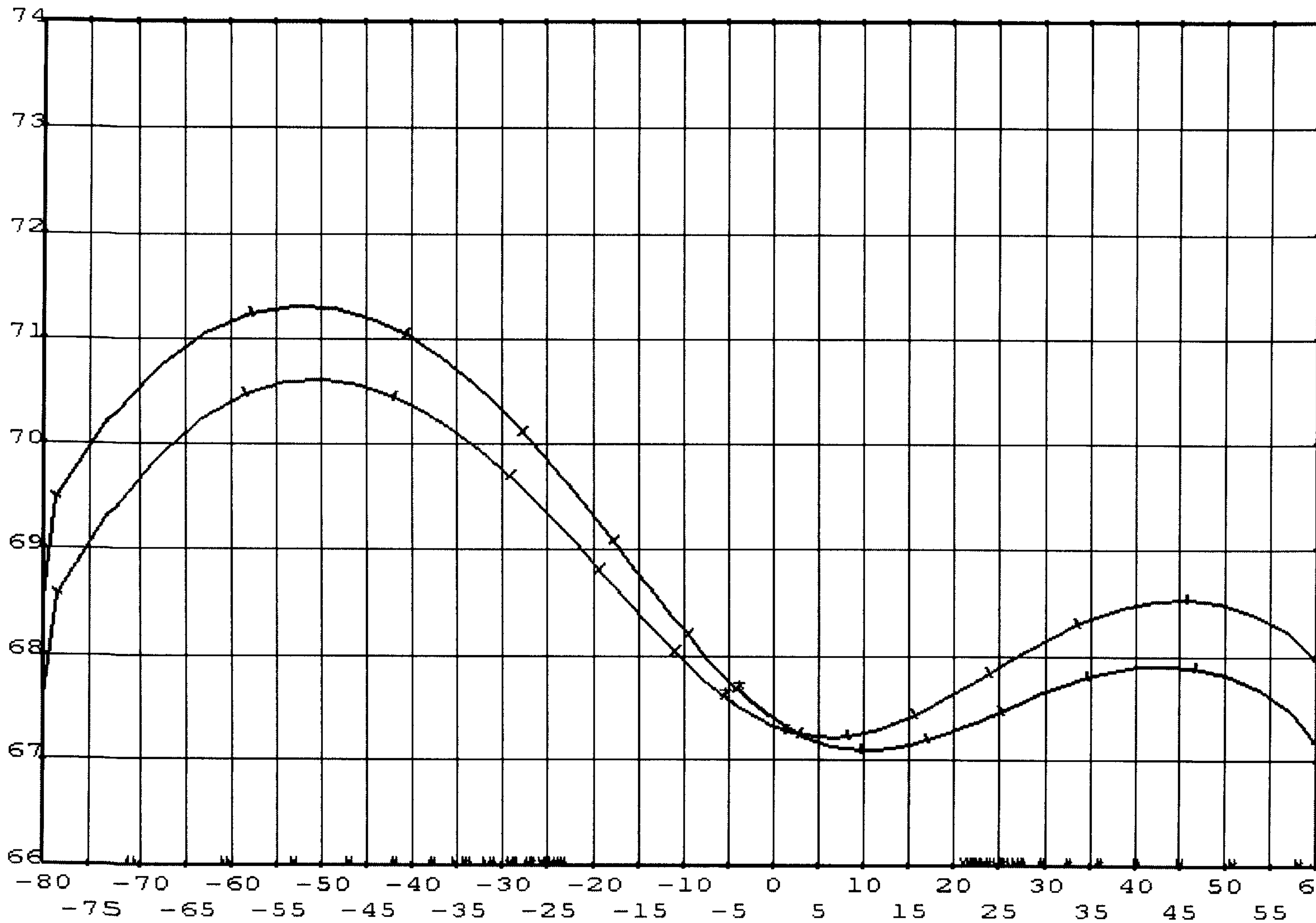
A Pass with Late Mean Anomaly (1°)



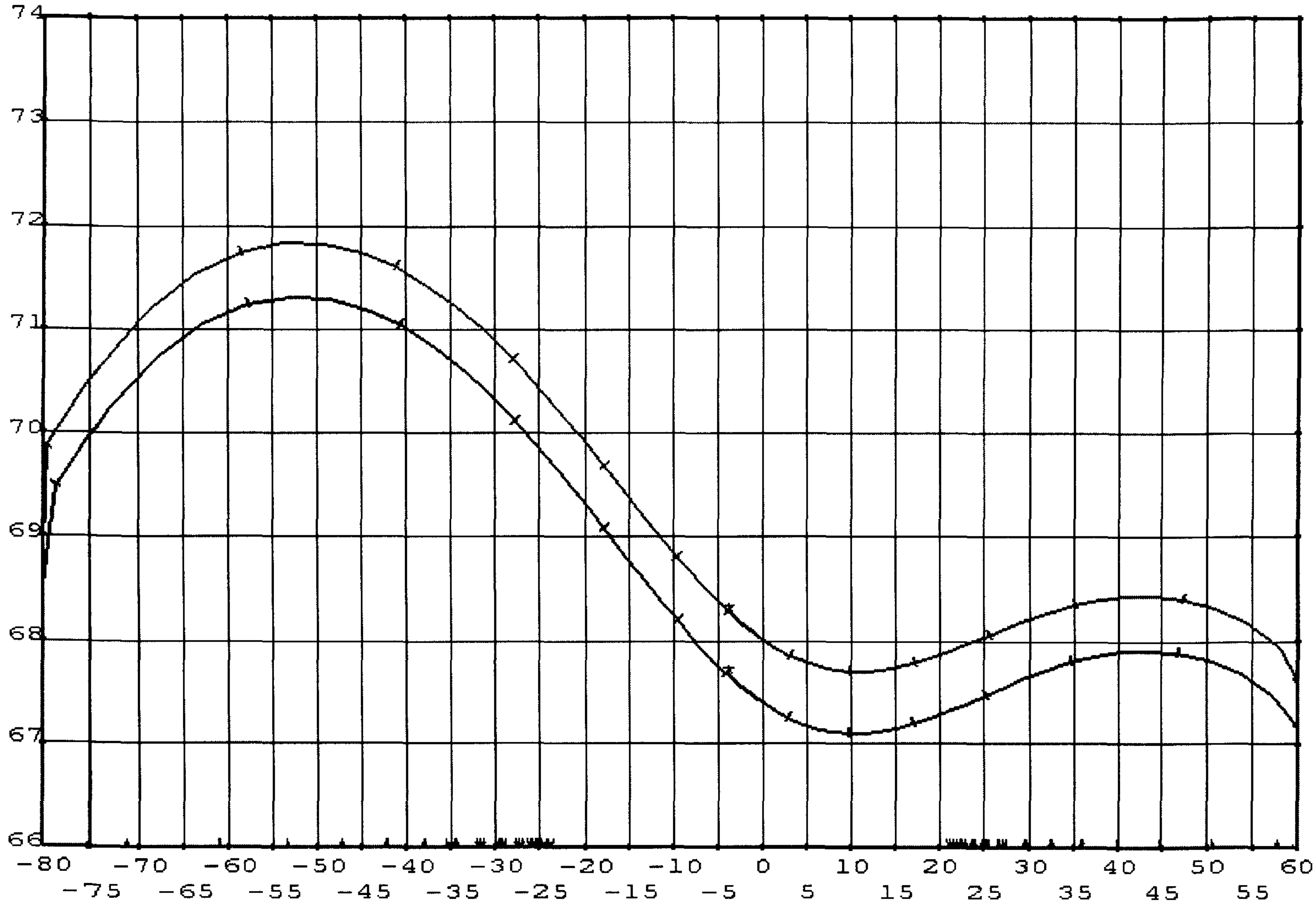
A Less Eccentric Pass (0.62)



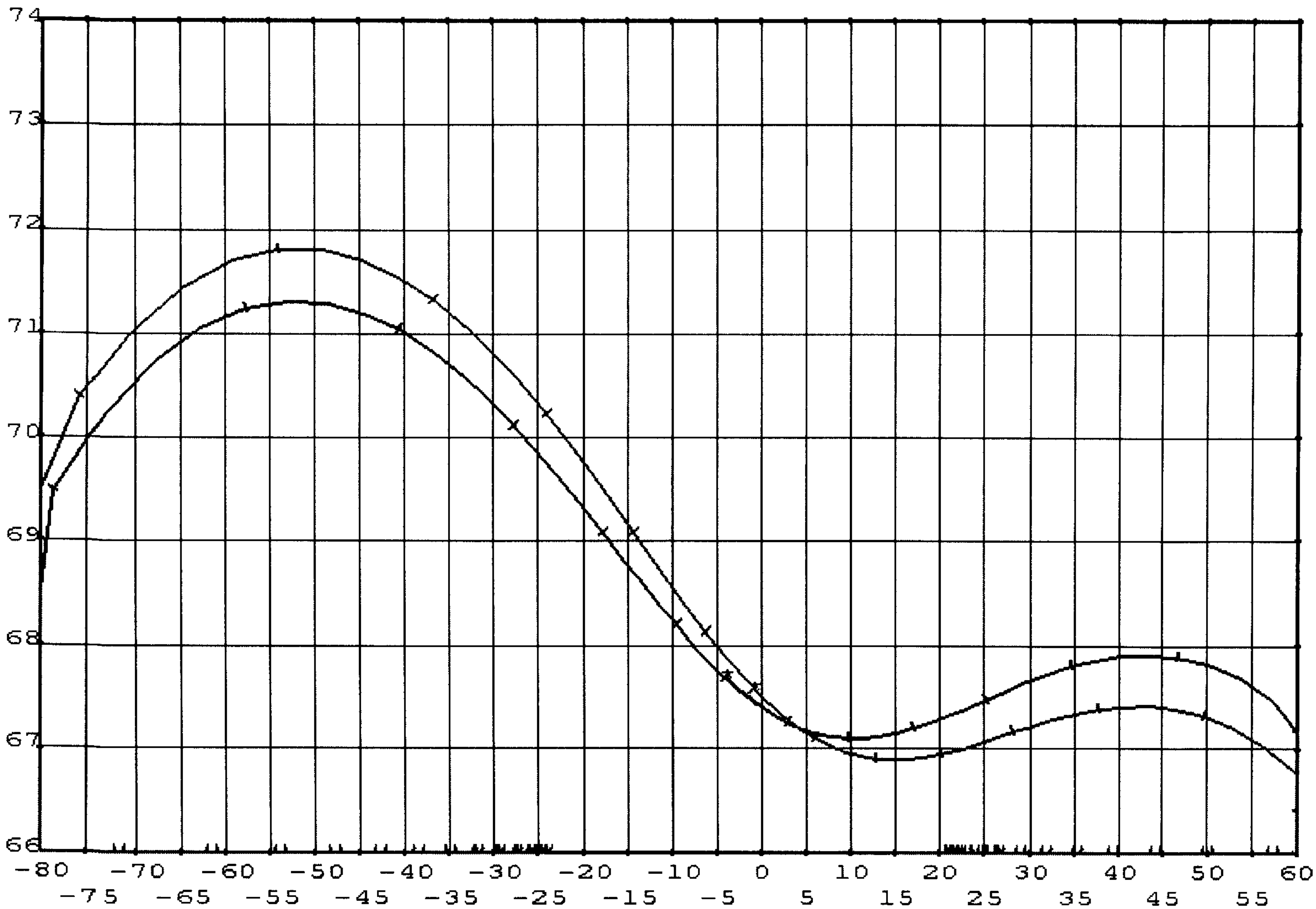
A Pass After
Regression of the line of Nodes (1° off)



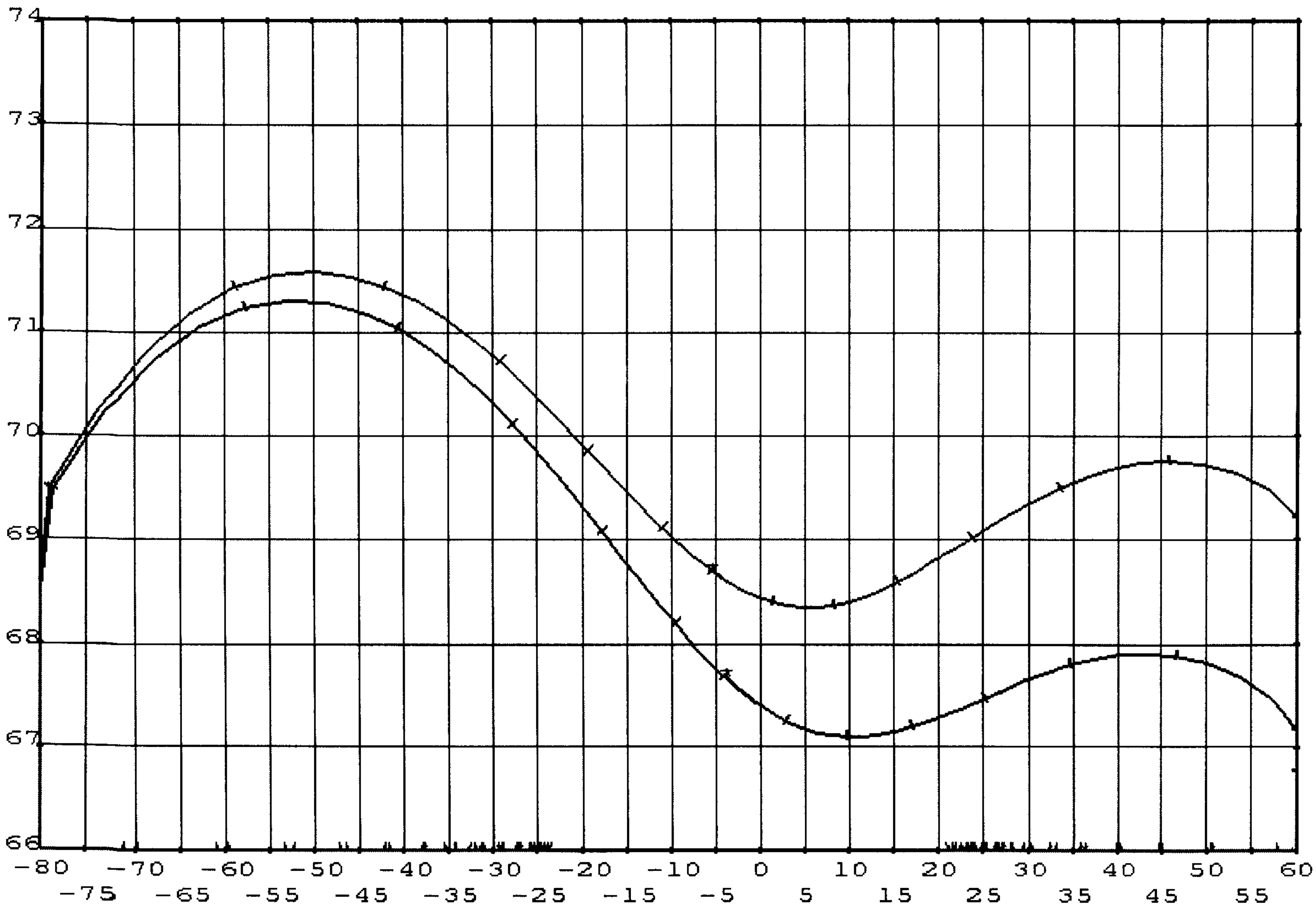
A Pass at Lower Inclination (by 0.5°)



A Shift in Argument of Perigee (by 1°)

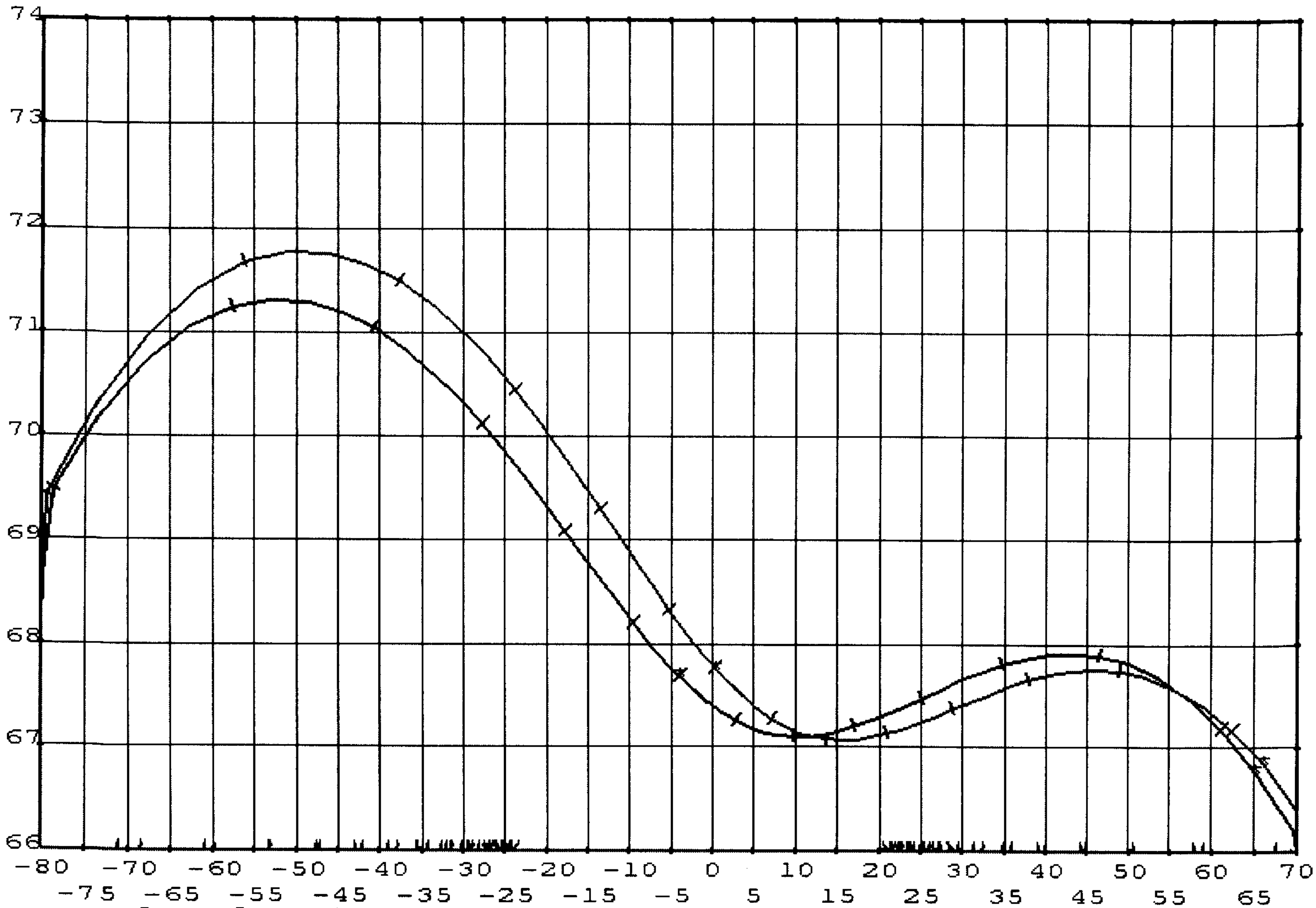


Keeping the Entry Point Fixed



... inadequate

Keeping Both Entry and Exit Fixed



… also inadequate

The Active Arc Tolerance Solution

- Keep Entry, Exit, and Midpoint Fixed?
  - Getting Complicated
  - Better is . . .
- Stay on Track throughout Active Arc.
  - Seen from any service area, at any point within Active Arc:
    - Intrack: Within 45 seconds of Standard point passage time
    - CrossTrack: Within 0.1 degrees of Standard path

- Simplest
- Results oriented
  - Stay on track and on time

Specification Objectives

- Easily understood assignment label for general use
  - Ground Track identity, definition, and
  - Time of Entry
- Easily understood orbital management for satellite operations
  - A conventional approach to defining a box
  - In-track, cross-track in active arc
  - How to get those results left to operator
- Keep it as simple as possible
  - Assigned numbers relate to <u>ground track</u> when applicable